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A CONNECTING LINK BETWEEN THE GEOLOGY OF THE NORTHERN SHAN STATES AND YUNNAN

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T. H. D. La Touche has described in detail the geology of the Northern Shan States west of the Salween River and up to latitude 23° north.¹ J. Coggin Brown has at one point extended this work farther north, having thoroughly mapped the section between longitudes $97^{\circ} 00'$ and $97^{\circ} 30'$ and extending north to latitude $23^{\circ} 15'$.² But beyond this area north to the border of Yunnan the ground has not been studied by the Geological Survey of India. North of the border in Yunnan the broader details of the geological structure have again been studied and mapped by J. Coggin Brown and made available in various survey reports.³

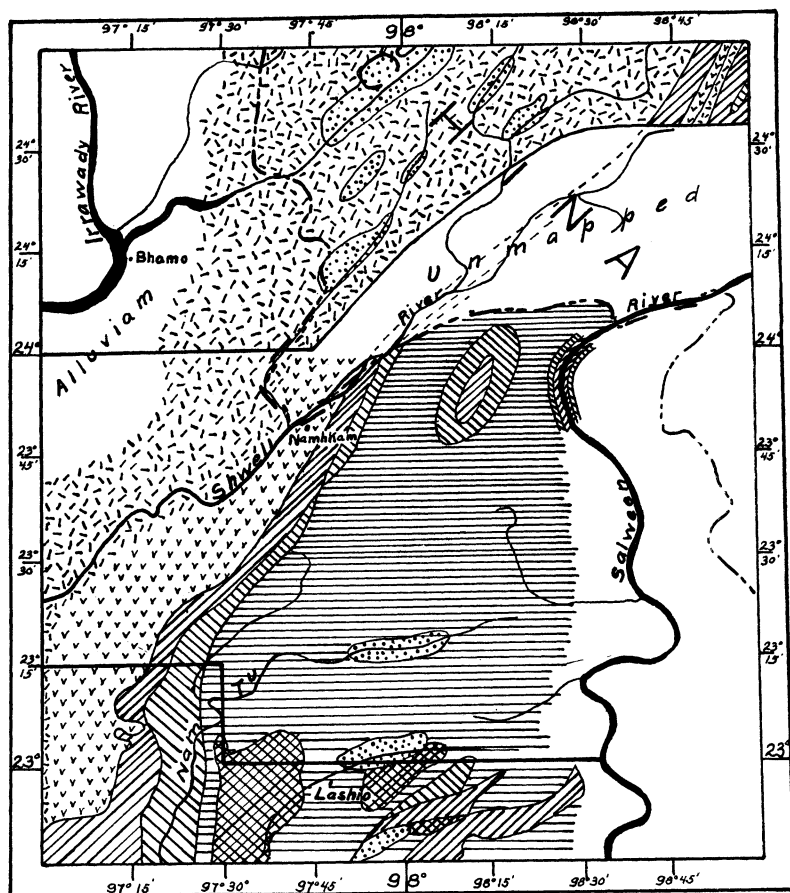
During the years 1917-18 the writer and several others, while doing exploration work for the Burma Mines, Limited, were enabled to take rough geological notes covering the unmapped area described above. By means of this work, as is shown on the accompanying map, the gap between the area in the South mapped by La Touche and Coggin Brown and that in Yunnan by Coggin Brown is partially filled in.

On the whole the section offers no points of marked difference from the areas to the south and north. Some slight differences between formations in Yunnan and the portions of the Northern Shan States familiar to him kept Coggin Brown from making definite

¹ T. H. D. La Touche, "Geology of the Northern Shan States," *Memoirs of the Geol. Surv. of India*, XXXIX, Part 2.

² J. Coggin Brown, "Geology and Ore Deposits of the Bawdwin Mines," *Records, Geol. Surv. of India*, XLVIII, Part 3.

³ J. Coggin Brown, "Contributions to the Geology of the Province of Yunnan in Western China: I, The Bhamo-Teng-Yueh Area," *Records, Geol. Surv. of India*, XLIII, Part 3, and other articles in the same series.



Geological map of a portion of the Northern Shan States

Upper Burma and Yunnan

Scale - 20 miles to an Inch



Mapped by
India & S. S. Unwin
Mapped by the
writer
Mapped by India & S. S. Unwin
Key to map

correlations. The area described here helps to explain these differences and assists in correlating the two sections. Owing to the strictly economic purpose of our work in the field no attempt to gather fossils was made, and consequently the mapping was done on strictly lithological grounds. The various formations have, however, with the exception of the Ordovician and Silurian beds, such definite lithological characteristics that their determination can be safely made without recourse to fossils. The Ordovician-Silurian beds are not mapped separately but are shown as a single formation between the known older slates and quartzites and the younger Devonian-Carboniferous limestone.

TABLE I
LIST OF FORMATIONS

Period	Name in the Northern Shan States and Character	Yunnan Equivalent
Recent	Alluvium—old river terraces—travertine	Nan Tien series
Subrecent		
Tertiary	Clays—sandrock and brown coal	Permo-Carboniferous and older Paleozoic limestones
Jurassic	Nam Yau series—red sandstones with limestone beds	
Permian	Plateau limestone—not differentiated into an upper and lower as by La Touche because of lack of fossil evidence	
Carboniferous		
Devonian	Namhsim, Naungkangyi, and other Silurian and Ordovician beds of La Touche grouped because of lack of fossil evidence, shales, sandstones, and some limestone beds	Pu-Piao series
Silurian		
Ordovician		Possible transition beds between Kao-liang and Pu-Piao Kao-liang series
Ordovician	Pangyun beds—not mapped by La Touche. Sandstones, shales, and occasional limestone beds	
Cambrian?		
Cambrian	Chaung Magyi—quartzites and shales	
Archean	Mogok gneiss with limestone bands	Crystalline series. Gneiss, granite and mica schist with a few limestone bands of Brown
Igneous	Granite—intrusive into gneiss and Chaung Magyi but age unknown. Basic dikes—intrusive into the granite	

In Table I are given the formations present in the area discussed. The same names are assigned to them as are used by La Touche in his *Geology of the Northern Shan States*. In the right-hand column are given what appear to be the corresponding formations in Yunnan. The names are those given by J. Coggin Brown in his reports on that province.

TOPOGRAPHY

The main structural features are the high mountain region of the western section (some of the peaks being over 7,000 ft.) composed of granite, gneiss, and the older Paleozoic sediments, and the

more open, less accentuated, topography of the Plateau limestone over most of the eastern section.

The Shweli in the North and the Nam Tu in the South both flowing in a general southwesterly direction are the dominant streams, carrying off all the drainage of the area, with the exception of a narrow strip along the eastern edge, where the streams flow east into the Salween. The Salween flows almost due south and, as is characteristic of it for most of its course through Yunnan and Burma, it has cut its way down far below the surrounding country and consequently has a very limited lateral drainage. The streams flowing into the Salween in this section have a length rarely exceeding thirty miles. Notwithstanding this fact it far exceeds any of the other streams in volume of water.

The abrupt change in the character of the country at the contact between the older Paleozoic sediments and the younger limestones is most pronounced, the former rocks standing up as a rampart across the whole area. In the isolated oval-shaped exposure of these rocks in the northeast corner of the Northern Shan States the same conditions hold, the older sediments rising up as a rugged, intricately dissected network of mountains out of the surrounding limestone country, which, by comparison, is of moderate relief, with wide valleys and rounded hills. The characteristic underground drainage of the limestone area has given rise to large sections, in which the topography consists of numerous sink holes of all sizes, inclosed basins in which the drainage disappears into the limestone. The same characteristic has also produced peculiar local topographic forms, such as hanging valleys without visible outlets and valleys with two distinct valley floors at different levels.

Certain sections of the granite area, in which the rock is of an extremely coarse-grained homogeneous nature, have weathered into a multitude of small, rounded hillocks without any definite drainage system. The streams wind sluggishly through the maze of small hills, often forming marshy lands. In this section the granite has weathered *in situ* often to a depth of several feet, leaving a soil composed of all the constituents of granite arranged in their normal position but unconsolidated.

ARCHEAN SYSTEM

The Mogok gneiss in this area is similar in every way to this rock as described by Barrington Brown and J. W. Judd in the Ruby Mines district and Coggin Brown in his traverse from Bhamo in Burma to Teng-Yueh in Yunnan. Consequently the section mapped here allows one definitely to connect those two areas. The gneiss is present in a great variety of types and often assumes both schistose and granitoid forms. All phases, from extremely acidic to basic hornblende gneisses, are found. Bands of coarsely crystalline limestone are present, as in the other areas of this rock. In fact, this band of igneous and metamorphic rocks maintains a great regularity in its diversity, whether examined far to the south of Mandalay (east of Pyawbwe in latitude $20^{\circ} 40'$) or in the North at Teng-Yueh in latitude $25^{\circ} 00'$. Noteworthy at widely separated points are the crystalline limestone beds. These limestones are of considerable interest, first in that they house an extremely varied collection of minerals, over twenty-five mineral species having been identified by Barrington Brown and Professor Judd, and secondly in that Professor Judd has argued in favor of the inorganic origin of the limestone by means of the alteration of the unstable scapolite contained in the basal gneisses. It would appear that the practical continuity of this crystalline limestone, in a well-defined zone more than two hundred and fifty miles in length is almost conclusive evidence of its original organic origin.

GRANITE

The granite is discussed at this point because, although considerably younger than the gneiss, being in fact intrusive into the Cambrian sediments, it is always found either entirely within the gneiss or along its eastern edges. On the map no attempt is made to show the granite areas within the gneiss. There are, however, no grounds for not believing that the large mass of homogeneous granite shown as occurring between the gneiss and the older sediments is not genetically the same as the very numerous bodies of granite found entirely within the gneiss area. The granite is a normal biotite granite and extremely consistent in its mineral character over large areas; extreme variations occur, however, in the texture from coarse-grained to fine-grained types. Intrusive

dikes of a basic type are common and in some localities cover an extensive area.

Coggin Brown in his work in Yunnan did not attempt to map the granite separately from the gneiss, but from the text it appears very probable that the band of granite separating the gneiss from the younger sediments south of the Shweli extends well north of that river into Yunnan.

The peculiar type of topography and accompanying excessive disintegration over a portion of the granite area has been mentioned previously.

CAMBRIAN (CHAUNG MAGYI)

These rocks differ in no respect from the descriptions of them in the neighboring sections, as given by previous writers. They consist of slaty shales, phyllites, and quartzites, severely folded and of rapidly varying strike. The band of rocks of the Kao-liang series mapped by Coggin Brown in Yunnan just east of the Shweli River in latitude $24^{\circ} 40'$ is undoubtedly a direct continuation of the Chaung Magyi of the Northern Shan States.

LATE CAMBRIAN-ORDOVICIAN-SILURIAN BEDS

These formations are all grouped together, as it is possible to separate them only by careful paleontological work. The oldest rocks of this group are of the most interest, as it is in the section under discussion that they attain their greatest importance. They have been called the Pangyun beds by Coggin Brown. No fossils have been found in them, but as they are conformably followed by Ordovician beds they are themselves either late Cambrian or early Ordovician.

It has been generally assumed by other observers that a decided break exists between the non-fossiliferous Chaung Magyi and the fossiliferous Ordovician strata, but it seems possible that this may have been due to the fact that favorable exposures of the intervening rocks had never been observed. In this area numerous sections were examined from the Chaung Magyi to the Silurian rocks, and no decided break could be found, the Pangyun beds apparently filling in the period between the Chaung Magyi and the fossiliferous Ordovician. In this connection it is interesting to note that limestone beds are present at various points in the Pangyun series.

Coggin Brown in discussing the Kao-liang system states that "lower down the eastern slope of the divide (Irrawady-Salween), silver-grey phyllites are interbedded with dark slates and bands of limestone. In the latter occurrence there is a marked difference from the Chaung Magyi system of the Northern Shan States, which otherwise they greatly resemble, for the former system does not contain lime in any form." On the assumption that the Pangyun beds are a transition series between the Chaung Magyi and the younger fossiliferous beds it is possible that the beds observed by Coggin Brown belong to this series and thus represent the passage from the Kao-liang system to the Pu-Piao series.

The younger Ordovician and the Silurian beds closely resemble those described by La Touche for the area to the south. They consist of sandstones, shales, marls, and occasional limestone beds. A detailed study of these beds in this section, with careful paleontological work, would undoubtedly allow of their being separated into their smaller subdivisions, as has been done by La Touche for the rest of the area.

The Pu-Piao series and the Silurian system in Yunnan of Coggin Brown are assumed as being analogous with the group of beds mapped here as lying between the Chaung Magyi and the younger limestones, with the slight difference that the bottom member (Pangyun beds) may belong both to the Kao-liang and the Pu-Piao.

DEVONIAN-CARBONIFEROUS-PERMIAN (PLATEAU LIMESTONE)

It has not been attempted to differentiate this formation, which covers a period from the Devonian to the Permian, into an upper and lower, as has been done by La Touche in the southern area. It is a direct continuation of the Plateau limestone mapped by him, and similar to it in all respects. In all the eastern section of the area it completely covers the older rocks except at two points, one in the northeast corner, where an eroded anticlinal mass has exposed the older sediments down to the Chaung Magyi, and the second in the gorge of the Salween, which river has cut its way down through the limestone and Silurian and Ordovician sediments into the Cambrian. At neither of these points are igneous or metamorphic rocks exposed.

As shown, this broad band of limestone continues into Yunnan and is thus directly correlated with the Devonian and Permo-Carboniferous limestone of that province.

JURASSIC (NAM YAU BEDS)

At one point in approximate latitude $23^{\circ} 47'$ longitude $98^{\circ} 15'$ on the flanks of the dome-shaped anticline in which the older sediments are exposed, beds of coarse conglomerates, with the pebbles largely of limestone, were noted. A short distance from this point extensive beds of red sandstone were encountered lying above the Plateau limestone. Their position and character are fairly strong evidence in assigning them to the Nam Yau, but the scant opportunity for examining them makes their definite determination unadvisable. This is especially true as they also resemble the Red Bed series of Yunnan (Permian-Triassic), as described by Coggin Brown, and may possibly represent a southern outlier of those beds.

No Jurassic beds have as yet been identified in Yunnan.

TERTIARY

Fairly extensive deposits of Tertiary beds are present in the Nam Tu valley, but they were not noted elsewhere, although it is possible that small remnants are present in some of the other valleys in the Plateau limestone. They are found as unconsolidated sands and clays and often contain extensive deposits of lignite and sub-bituminous coal.

RECENT

All the more prominent river valleys are covered with deposits of recent alluvium, probably with the exception of the Shweli valley in the Namhkam area, always of fluvial origin. In the case of the Shweli valley the broad plain about thirty miles long, with an average width of five or six miles, probably represents an old lake bed similar to the numerous ones which have been noted in Yunnan. Recent elevation with consequent renewed erosion by the Shweli has largely concealed its former character.

It has not been attempted to show these deposits on the accompanying map, as it only tends to confuse the relations of the underlying consolidated formations.